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Case Series

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Treatment of high-output cardiac failure secondary to anemia in three cats

Hillary Hammond[1] and Kursten V Pierce[2]

Abstract

Case series summary Three cats presented for clinical signs of respiratory distress and varying etiologies of anemia. Echocardiograms revealed evidence of cardiac dilation without other significant structural or functional heart disease. Thoracic imaging via point-of-care ultrasound and/or radiographs confirmed evidence of volume overload by pleural effusion. Each cat was diagnosed with presumed high-output cardiac failure secondary to anemia. Mainstays of treatment included controlling congestion and correcting the anemia with transfusions in the short-term while addressing the underlying etiology of the anemia in the long-term.

Relevance and novel information Reports, treatment and management of high-output failure in the veterinary literature are limited. Extrapolating from human medicine, cats presenting with anemia and findings consistent with volume overload will benefit from treatment of their anemia to reduce neuroendocrine activation and the associated sodium and water retention. Therefore, blood transfusion should neither be avoided nor delayed in anemic cats with changes consistent with volume overload and congestive heart failure.

Keywords: Heart failure; pleural effusion; cardiology; anemia

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Case series description

Case 1

A 9-year-old female spayed domestic shorthair (DSH) presented for acute tachypnea and lethargy. At presentation, packed cell volume (PCV) was 16% (reference interval [RI] 31–48) and total protein (TP) was 6.0 g/dl (RI 5.9–7.5). All other findings on complete blood count (CBC) were within the RIs. Total thyroxine (TT4) was 0.5 µg/dl (RI 0.8–4.7), likely euthyroid. Systolic blood pressure obtained via Doppler was 95 mmHg (RI 110–132).[1] Thoracic radiographs (Figure 1) were concerning for congestive heart failure (CHF), as evidenced by an enlarged cardiac silhouette and diffuse interstitial pattern (Figure 1a,c). Thoracocentesis yielded 20 ml clear transudate. The cat was administered furosemide 1 mg/kg IV. An echocardiogram revealed dilation of all chambers with appropriate function, mild residual pleural effusion and mild pericardial effusion (Table 1).[2,3] An abdominal ultrasound (AUS) demonstrated a focal multilobulated duodenal mass that was highly vascular and bled during sampling. A presumptive diagnosis of high-output cardiac failure was made based on lack of inherent structural or functional heart disease, pleural effusion and severe anemia. The cat was hospitalized with oxygen and administered additional furosemide 0.5 mg/kg IV every 6–8 h. A cross-matched transfusion (type B) of 45 ml packed red blood cells (RBCs) was administered over 10 h. The immediate post-transfusion PCV was 25%. The duodenal mass was removed the following day via exploratory laparotomy. The cat received supportive care postoperatively, including maintenance fluids (lactated Ringer's solution [LRS] 5 ml/h IV + 30 mEq KCl) and pain medications (fentanyl [2 µg/kg/h IV] and gabapentin [8 mg/kg PO q12h]).

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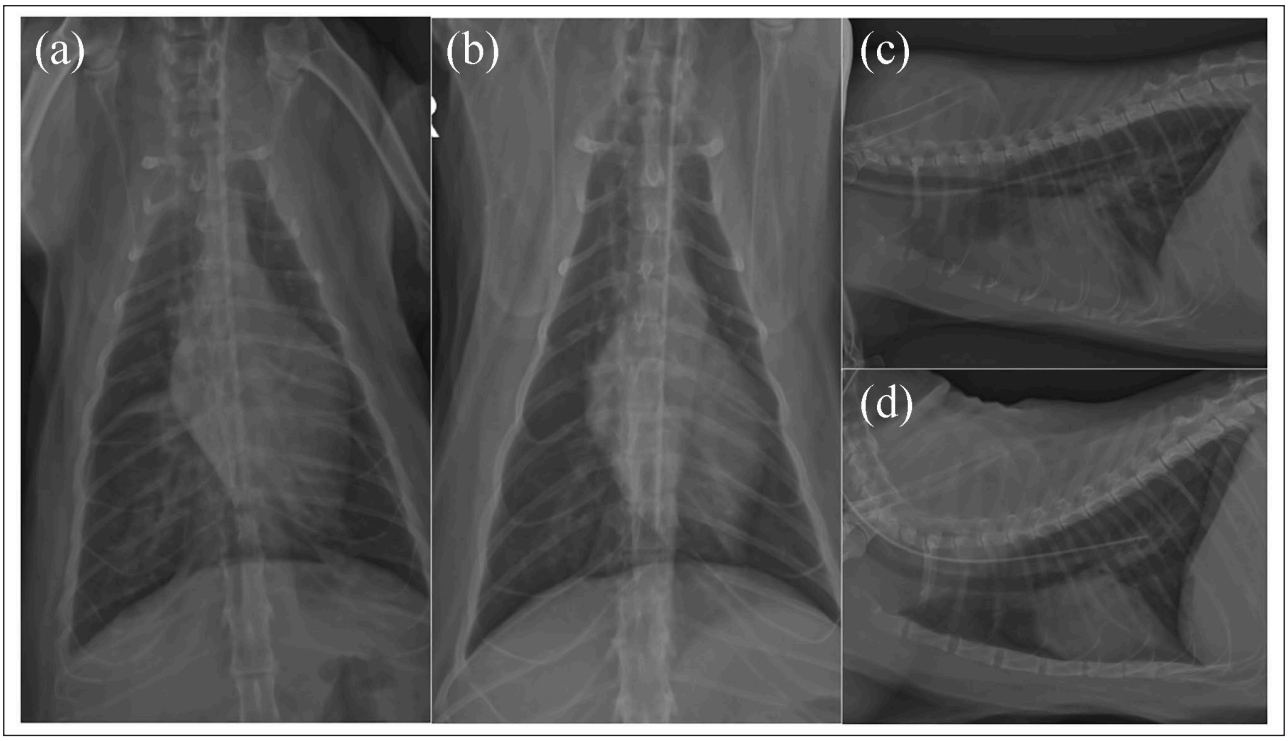

Figure 1 Thoracic radiograph images from the cat in case 1. (a,c) Ventrodorsal and lateral radiographs when the cat's packed cell volume was 16%. There is an enlarged cardiac silhouette, an unstructured interstitial pattern in all lung lobes, which was worse in the caudal lobes, and a small volume of pleural effusion. (b,d) Ventrodorsal and lateral projections when cat's anemia was resolved. The cardiac silhouette is normal and resolution of the interstitial pattern is noted

Table 1 Echocardiographic parameters for cats (cases 1, 2 and 3) at the time of presumptive diagnosis of high-output cardiac failure

Case	LA (RI 13.03–15.95 mm)*	LVIDd (RI 12.24–16.22 mm)†	IVSd (RI 4.32–6 mm)†	LVFWd (3.83–6 mm)†	FS% (32–68)†
1	19.3	16.4	6	5.3	65.7
2	16.6	18.4	3.8	3.4	57.1
3	17.4	18.2	5.2	5.8	59.9

*As measured in right parasternal four chamber long axis
†As measured in right parasternal short axis
LA = left atrial diameter; RI = reference interval; LVIDd = left ventricular internal diameter in diastole; IVSd = interventricular septum in diastole; LVFWd = left ventricular free wall in diastole; FS% = fractional shortening

A recheck PCV the next day remained stable at 29%. Owing to resolution of tachypnea, oxygen and furosemide were discontinued. The cat was discharged and follow-up occurred with the referring veterinarian 1 week later. Thoracic radiographs at that visit revealed a reduction in cardiac size and no evidence of CHF (Figure 1b,d). A recheck PCV 1 month postdischarge was 45%.

Case 2

A 5-year-old female spayed DSH presented to urgent care following a suspected dog attack. The cat presented laterally recumbent with multiple wounds in the hind end and an initial PCV of 25%. CBC showed neutrophilia ($13.3 \times 10^3/\mu l$, $0.5 \times 10^3/\mu l$ myelocytes, $0.7 \times 10^3/\mu l$ metamyelocyte, $5.8 \times 10^3/\mu l$ bands) and a moderate number of giant neutrophils indicative of leukocytosis with left shift, suggesting systemic inflammatory response secondary to trauma. Thoracic radiographs revealed a mild pneumothorax and normal cardiac silhouette (vertebral heart score 7.4). To evaluate for underlying structural heart disease and influence fluid recommendations, an echocardiogram was performed, which showed no cardiac enlargement or cavitary effusions (Figure 2a). The cat was treated with oxygen, intravenous fluids (LRS 10 ml/h + 2.5% dextrose + 0.1mEq/kg/h KCl) and antibiotics (Ampicillin/sulbactam 30 mg/kg IV q8h).

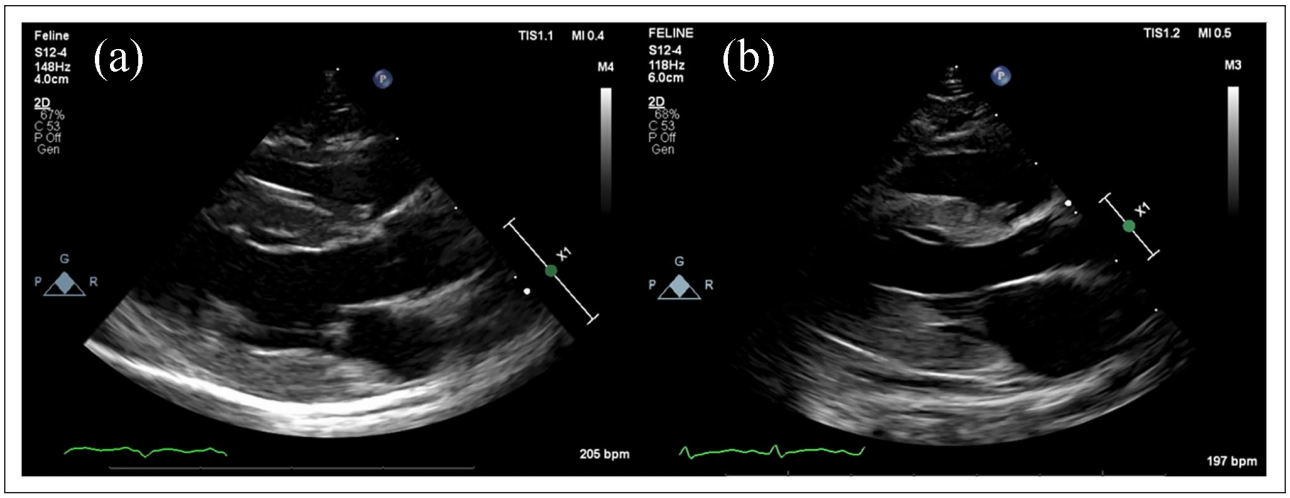

Figure 2 Echocardiographic images from the cat in case 2. (a) Right parasternal left ventricular outflow view when the cat's packed cell volume (PCV) was 23%, showing no cardiac chamber enlargement or cavitary effusions. (b) Right parasternal left ventricular outflow view 12 days later when cat's PCV was 19%, demonstrating progressive left atrial enlargement and dilation of the right ventricle. Mild pericardial effusion can also be seen

The cat was weaned off oxygen after the first day and discharged after 2 days. The cat returned 12 days later for worsened lethargy, tachypnea and dyspnea. The PCV and TP on presentation were 19% and 5.6 g/dl, respectively. Point-of-care ultrasound (POCUS) revealed mild pericardial and pleural effusion. A recheck echocardiogram revealed dilation of all chambers with appropriate systolic function (Figure 2b and Table 1). There was trace pericardial, mild pleural and mild abdominal effusion. A presumptive diagnosis of high-output cardiac failure was made, and the cat received 1 mg/kg furosemide intravenously. Blood type and cross-match were performed prior to transfusion of 30 ml packed RBC administered over 8 h. A recheck PCV was improved at 23%, and the cat's respiratory signs resolved. The cat was discharged with furosemide (2.1 mg/kg PO q12h for 7 days). No recurrence of respiratory signs occurred after the discontinuation of a diuretic, and the cat's anemia did not recur at the time of follow-up 3 months later.

Case 3

An 8-year-old male castrated DSH presented for severe anemia and pleural effusion. Mucous membranes were pale on presentation. POCUS revealed an enlarged left atrium, pericardial effusion and B-lines. PCV and TP were 11% and 8.5 g/dl, respectively. CBC revealed a non-regenerative or pre-regenerative (reticulocytes $20.3 \times 10^3/\mu l$) anemia, with severe thrombocytopenia ($46 \times 10^3/\mu l$) and moderate spherocytes. Feline immunodeficiency virus/feline leukemia virus, heartworm test, TT4, AUS and feline fever panel were performed with negative/normal results. Echocardiogram revealed dilation of all chambers with appropriate systolic function, mild pericardial effusion and mild pleural effusion (Table 1). The cat received no diuretics or transfusions overnight. The following day, the cat was lethargic and hyporexic. Crossmatch and blood type were performed, and 41 ml packed RBC were given over 8 h. Post-transfusion PCV was 15%. The cat's energy and appetite returned. POCUS showed persistent mild pleural effusion. The cat was discharged with prednisone (0.86 mg/kg PO in the morning and 0.43 mg/kg PO in the evening). Three days later, the cat returned, presenting with tachypnea and dyspnea. PCV/TS and CBC were reassessed, and the anemia appeared static (PCV 14%, hematocrit 14%, reticulocytes $6.7 \times 10^3/\mu l$). A moderate amount of bilateral pleural effusion was noted on POCUS and 90 ml pleural effusion was removed via thoracocentesis. A presumptive cause of the effusion was high-output cardiac failure secondary to an immune-mediated anemia, given lack of positive infectious diagnostics. Medical management of effusion was recommended with furosemide (1.1 mg/kg PO q12h). A recheck 1 week later showed no residual effusion but worsening anemia of 10%. A second transfusion of 45 ml packed RBCs was administered over 10 h and the cat was transitioned to sodium phosphate (0.21 mg/kg PO q24h) and ciclosporin (5.8 mg/kg PO q12h). Furosemide was continued at the previous dose. Although suspected to be immune-mediated in origin, the anemia was unable to be resolved, despite diuretic and immunosuppressive therapy, and the cat continued to receive intermittent transfusions. Furosemide was continued without need for up-titration based on lack of significant effusion on POCUS and respiratory rate. The cat's anemia did not improve, and the cat was euthanized 6 weeks later.

Discussion

Cardiac failure is often characterized by a reduction in systolic and/or diastolic function with increased systemic

vascular resistance (SVR). On the contrary, high-output failure cats have normal cardiac function with decreased SVR secondary to the body's increased demand for perfusion.[4] The reduction in arterial afterload can be due to bypass of the arterioles and capillary beds via arteriovenous fistulas or secondary to systemic pathologies resulting in peripheral vasodilation, such as anemia (as described above), liver disease, morbid obesity, myelofibrosis, pregnancy and hyperthyroidism.[5] With a decline in hemoglobin, there is a decrease in the oxygen-carrying capacity of the blood and adjustments are made to maintain tissue oxygenation, including high cardiac output. Low blood viscosity and increased nitric oxide synthase lead to arterial underfilling or decreased SVR.[6] As a sequela, there are complex compensatory mechanisms, including activation of the renin–angiotensin–aldosterone system, excess antidiuretic hormone and increased sympathetic activity that leads to sodium and water retention, creating an increased intravascular volume.[7] With chronicity, recruitment of collateral circulation and the increased cardiac preload can contribute to the enhanced cardiac output leading to increased end-diastolic volume, and induce eccentric hypertrophy and possible cardiac failure.[8] In severely anemic cats, as in this case series, left heart dimensions have been shown to be increased vs those with mild anemia.[8,9] These cats also demonstrated normal systolic function making a dilated cardiomyopathy phenotype less likely and therefore anemia more likely as a contributing factor to the clinical signs that developed.

Reports of high-output failure in the veterinary literature are sparse and provide little information on targeted treatment and management in cats showing clinical signs. Extrapolating from human medicine, the mainstays of treatment for high-output failure induced via anemia include controlling the congestion and correcting the anemia in the short term, while addressing the underlying etiology of the anemia in the long term.[4,6] Treatment of respiratory signs are dependent on severity, and range from standard CHF treatment of intermittent diuretic therapy and oxygen supplementation to continuous diuretic infusion, non-invasive positive pressure ventilation, thoracocentesis or even intubation.[6] In this case series, two of the cats required emergency thoracocentesis for relief of dyspnea. All cats were treated with bolus diuretic therapy of furosemide 1 mg/kg q6–12h intravenously or orally until respiratory signs resolved. The decision for intermittent therapy over continuous rate infusion was based on clinician preference. Although not seen in the cats above, if hypotension or decreased organ perfusion is evident, vasopressor support may be warranted to combat the decreased SVR.

Although seemingly counterintuitive to administer a blood transfusion to a cat with evidence of volume overload, in humans, correction of anemia with CHF reduces the mortality and hospitalization rate.[10] Similarly, cats presenting with anemia and findings consistent with volume overload appear to benefit from treatment of their anemia, which reduces neuroendocrine activation and associated sodium and water retention. Therefore, blood transfusion should neither be avoided nor delayed in anemic cats with changes consistent with volume overload and CHF.[8,9] All cats received a packed RBC transfusion owing to primary concern of low blood viscosity and associated arterial underfilling. Blood component therapy should be taken into consideration in any patient requiring a transfusion. The transfusion time was extended to 8–10 h, to reduce the risk of contributing to volume overload in the acute setting. Two cats also received a single dose of diuretic prior to initiation of transfusion, aimed at reducing the dyspnea and tachypnea.

While treating the congestion and increasing the hematocrit are the primary goals of short-term treatment, identifying and addressing the underlying etiology of anemia via additional medical and/or surgical interventional procedures is imperative.[6] In cat 1, removal of the bleeding duodenal mass resolved the anemia and further interventions were not necessary. In cat 2, the anemia was presumed to be secondary to the dog attack and secondary complications from healing, and therefore was not a long-term primary disease that warranted further interventions. In cat 3, the anemia was suspected to be immune-mediated in origin and therefore was treated with immunosuppressive doses of steroids. Although it is seemingly counterintuitive to administer steroids given the association with increased water retention, the aim of addressing the underlying etiology of anemia was deemed most appropriate; however, the cat's PCV did not improve, and long-term diuretics were necessary. In the two cats in which the anemia resolved, the effusion was reduced and diuretics were no longer needed within 1 week. It is unclear if the severity of anemia unilaterally correlates to the chamber size or if factors such as the rate of onset or duration prior to development of signs may also play a role.[8,10] Further studies are needed to evaluate the correlation between time, severity and onset of high-output cardiac failure. While the prognosis of high-output cardiac failure is dependent on the cause of the condition, the cats in this case series are supportive of resolution of the anemia, resulting in resolution of the high-output cardiac failure in an acute setting.

Conclusions

Cats presenting with anemia and findings consistent with volume overload will benefit from diuretics to reduce associated sodium and water retention and treatment of their anemia to reduce neuroendocrine activation. Therefore, blood transfusion should neither be avoided nor delayed in anemic cats with changes consistent with volume overload and CHF.

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Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognized high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS Open Reports*. Although not required, where ethical approval was still obtained it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of the animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

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